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June 2004

# Fatigue and Use of Go/No-go Pills in F-16 Pilots Subjected to Extraordinary Long Combat Sorties

We lack knowledge of real world pilot fatigue and use of Go/No-Go (USAF terms for stimulants/ sleep aids) pills. To analyze this, a forward-deployed flight surgeon studied fighter pilots subjected to combat sorties often longer than 8 hours in duration. A 49-question survey on fatigue and Go/No-go use was distributed to 19 deployed/two permanent party fighter pilots during the end of a 3-month deployment. The data was analyzed by the USAF Research Laboratory, Fatigue Countermeasures Branch. Results showed that the pilots flew an average of 149.0 hours over 3-months. To enhance crew rest, the flight surgeon made the sleep aids zolpidem (Ambien) and temazepam (Restoril) readily available to pilots.

Fifteen pilots reported using zolpidem. Sleep aids were reported as being effective, but pilots had varied perceptions about their relative effectiveness. There was a statistically significant negative trend for frequency of sleep aid use frequency as a function of pilot use during long sorties (longer than 8 hours). Pilot month. Sixteen pilots reported using dextroamphetamine and/or prior to landing. Seven of 16 dextroamphetamine use.

We conclude that fatigue is a significant safety threat in sustained fighter combat operations. We recommend that proper use of Go/No-go pills can help mitigate this risk.

“Overall, the alertness aid was perceived as being effective.”

Schultz D., Miller JC Technical report AFRL-HE-BR-TR-2004-0014x, Air Force Research Laboratory, Brooks City-Base TX, April 2004.

Schultz D, Miller JC (2004). Fatigue and use of go/no-go pills in extraordinarily long combat sorties (Commentary). *Aviation Space Environ Med* 75(4):370-371

-- Dr. J. Miller



# Assessing Complex Team Performance in a Sustained Operations Environment

Research of individual and team command, control, communications, computers, information, surveillance and reconnaissance (C4ISR) decision making, coordination and performance under fatigued conditions over time resulted in several lessons learned.

A sample of the results, provided in the paper, indicate both

individual and team-level effects of fatigue on performance. The discussion is focused on measurement and modeling of complex team behaviors and some of the difficulties involved. Air Force command and control (C2) warfighters face increasingly complex environments that represent the essence of naturalistic decision making. In tactical C2 situations, the focus is on dynamic battle management and time-critical targeting.

Information updates may be from air or from ground sources. Coordination demand is high: reconnaissance and resource allocation depend on close coordination between ground and air forces in a distributed network. These situations, requiring close coordination and adaptive replanning, are increasingly prevalent and challenging. Significant research and investment in advanced technology allow for real-time information flow of tactical information, both horizontally (across functions) and vertically (up and down the chain of command). These capabilities enable shared situation awareness and coordinated response within complex battlefield situations. However, it should be emphasized that technology can only support, not replace, the role of the warfighter. Advanced

technology enables closer coordination and accuracy of long-range weapons—yet it also increases the demand for human performance—for close team and multi-team coordination, shared situation awareness across numerous and diverse units, and rapid replanning across units, in hostile, dynamic, time-critical and long-duration situations. Basic performance measures showed effects of fatigue at the individual level, agreeing with decades of fatigue research. For the first time ever using objective measures, team performance was shown to vary similarly. Both process measures and outcome measures were significantly affected by fatigue. The results of the study proved useful in understanding the effects of fatigue on performance, which is a crucial field of research for those who endure sustained operations. Moreover, while advanced technology affords paradigm shifts in information technology, it cannot replace C2 decision makers or troops on the ground, who must make tactical decisions under duress and often for sustained periods of time. Despite any particular advanced technology, this paper assesses complex team performance within the context of U.S. Air Force command and control (C2) operations under the condition of sleep loss.

**“...the results will form the initial foundation for recommendations to military personnel on how to manage team fatigue and maintain effective decision making in dynamic and complex environments.”**

*Barnes, C., Whitmore, J., Harville, D., Elliott, L. (2004) Assessing team performance in a sustained operations environment. The ITEA Journal of Test and Evaluation. March/April (25) (1).*

-- 1Lt C. Barnes

## **Fatigue in Aviation Special Operations: Understanding the Problem and Possible Ways to Fix it**

Fatigue in aviation operations is a safety hazard. More and more is discovered about the number and sheer magnitude of fatigue-related mishaps in both military and civil aviation. In the Air Force alone, almost 8 percent of the reportable Class A mishaps over the past 20 years have been at least partially blamed on aircrew fatigue. But, regardless of the fact that fatigue has become a well-recognized operational hazard, many people remain unclear about the exact nature of the problem and what techniques are most likely to effectively counter it. The article written by Dr. J. Caldwell defines fatigue, discusses circadian rhythm, and gives tips in dealing with fatigue. Needless to say, if we could just avoid sleep loss, shiftwork, and time-zone changes, we could eliminate fatigue from every mission. However, given the nature of military operations, it's difficult to imagine that such a perfect world will ever exist. So, what can be done? There are a variety of strategies for managing fatigue in operational settings, and these are generally categorized as either non-pharmacological or

“...improperly managed fatigue is an ever-present threat to operational safety and effectiveness.”

pharmacological (non-drug versus drug). The top non-pharmacological fatigue countermeasures are: good sleep habits, proper work/rest management, strategic naps, rest or activity breaks, brief periods of exercise, and computerized scheduling tools. When none of the non-pharmacological approaches seem to be enough to maintain performance at safe effective levels, anti-fatigue drugs can be a short-term solution. Although drugs should never be used

in place of good crew-rest planning, there are situations in which “alertness-enhancing compounds” are the most reliable method. At present, there are essentially three choices that deserve serious consideration – caffeine, Modafinil, and dextroamphetamine. Fatigue will always be a problem in Special Operations because of the intensity and unpredictability of the missions undertaken. **THE BOTTOM LINE IS THAT!** This article can be found in full text in the FOCUS AFSOC Commando Safety Journal.

<https://www.afsoc.af.mil/milonly/safety/focus.htm>

-- Dr. J. A. Caldwell

## The Effects of Fatigue on Simulation-based Team Decision Making Performance

This study examined the effects of fatigue on team decision-making performance in a command and control context. Ten three-person teams participated in an investigation of sleep deprivation on physiological state, cognitive function, and simulation-based performance. Teams participated in the study from 6:30 pm through 10:30 am the next morning. In this report, we describe preliminary analyses, focused on effects of sleep loss. Despite the small number of teams, significant results were found with regard to time, scenario, oral temperature, and math total points.

Very few studies report data regarding sleep loss effects on particular aspects of information processing in complex decision-making tasks. Even fewer have reported effects on team performance; however, a few preliminary studies, based on team simulation-based performance, provide some introductory results. To continue this stream of research, we have initiated a program of research on effects of sleep loss on information processing, communication, coordination, and decision-making in complex simulation-based tasks.

“It is already clear at this point that fatigue has an effect on team performance.”

Results suggest a decrease in cognitive capacity under fatigued conditions, which shows effects at both the individual and team levels, consistent with circadian rhythm models. It was also expected that more of the cognitive battery tests would be associated with the team scores, but only the math total points scores were significant.

Further stages of this study are currently in the planning process. The next stage will increase the sample size, providing more statistical power. It is encouraging that significant results have already been found at this early stage, and it is expected that future stages will further clarify the effects of fatigue on team performance. Future steps will include better quantifying these effects and eventually creating strategies to minimize and counter such effects. Other analyses utilizing data collected as a part of these efforts are currently being conducted, including communications analysis and command and control scenario process and outcomes measures.

Barnes, C., Elliott, L., Coovert, M., Harville, D. (2004) *Effects of fatigue on simulation-based team decision performance*. *Ergometrika*, 4 (2-120) <http://www.ergometrika.org/volume4/toc.html>

## Jet Lag and Shift Lag: How can we maintain Performance?

There are problems, and potential solutions, which are useful when an individual needs to work at night (leading to shift lag) or is deployed across multiple time zones (leading to jet lag). Each of us has an internal mechanism called a biological clock that mediates the biological and psychological processes that naturally vary over the 24-hour day. These processes are termed "circadian rhythms." Examples of some of the rhythms are body temperature, hormone secretions, and alertness, but there are literally thousands of processes within us that have a daily pattern. These are kept in sync by a number of cues that naturally occur within our environment. Light is the primary cue responsible for maintaining consistently synchronized internal rhythms, but other cues can contribute to the daily cycle, as well. Working non-standard hours is fraught with difficulty, and the reasons are almost entirely physiological. To understand the difficulties faced by nightworkers, consider the fact that much of the ability to sleep at any point in the 24-hour cycle depends on the time at which sleep is initiated. It is easy to see that getting enough sleep during the day is difficult, but staying alert during the night is also a tough problem. Another way that people encounter circadian disruptions is through the rapid crossing of multiple time zones. Technically, jet lag is a problem when the environmental time cues are at least 3 hours different from the biological clock. Some countermeasures for shift lag: use caffeine CAREFULLY and wait until you need a boost, use social interactions and physical activity/postural changes to help stimulate your environment, stay cooler than usual, prepare in advance for changes in sleep schedules by gradually adjusting your sleep time, ensure clockwise transitions when changing work schedules and make sure personnel have adequate time for sleep before reporting to next duty shift. Some countermeasures to help you sleep during the day, avoid caffeine 4-6 hours before bedtime, avoid sunlight after a night shift and during the day when trying to sleep, avoid alcohol and strenuous exercise for at least 3 hours before bedtime, make the bedroom cool and very dark, remove the phone from the room and discourage daytime visitors, use earplugs and masking noise to cover outside distractions, and consider the use of sleep medications to help sleep during the day. The basic strategies for getting a body's rhythms adjusted to a new work/sleep schedule after traveling to a new time zone are the same as the ones suggested for readjusting shift workers. You must decide if it is worth the change. If only 1-3 days will be spent in the time zone, it is best to remain on the original schedule. The bottom line is that the body will revolt when the circadian rhythm is disrupted for any reason. Taking care of some of the manageable variables will lead to improved safety on the ground and in the air, better work performance, better relationships and better general health.

**"There are countermeasures for shift lag, as well as jet lag."**

This article can be found in full text in the FOCUS AFSOC Commando Safety Journal Spring 2004 <https://www.afsoc.af.mil/milonly/safety/focus.htm>

-- Dr. J. L. Caldwell

## F-117 fatigue countermeasures research results transitioned to ACC operational units

AFRL findings and recommendations from a recent Holloman AFB F-117 simulator study enabled ACC/SG to transmit operations-significant direction to the field to reduce mishaps and improve pilot performance. Only six weeks after completing data collection for the study "The Efficacy of Modafinil for Sustaining Alertness and Simulator Flight Performance in F-117 Pilots During 37 Hours

of Continuous Wakefulness,” AFRL published crucial findings and made associated recommendations to the AF Surgeon General's Office. The ACC Surgeon General's Office swiftly messaged all eligible units and recommended flight surgeons immediately apply AFRL's findings to operations.

-- Dr. J. A. Caldwell

## Studies and Projects:

*Several of the WFC Team presented at the Aerospace Medical Association (AsMA) Conference in Anchorage, Alaska 2-6 May 04*  
<http://www.asma.org/meetinginfo.html>

Predicting Flight Performance with Select Physiological and Cognitive Measures  
Dr. J. L. Caldwell and Dr. J. A. Caldwell

The Physiological, Cognitive, Mood, and Simulator-Flight Performance Effects of 37 Hours Continuous Wakefulness in F-117 Pilots  
Dr. J. A. Caldwell, Dr. J. L. Caldwell, Col D. Brown, and 2Lt J. Smith

Assessing Overconfidence Under Modafinil Using Cognitive Performance Estimation  
Dr. D. Eddy and NTI, Incorporated

Methodological Aspects of Quantifying Piloting Capability on the Primary Task: Aircraft Control  
Dr. J. A. Caldwell

Modafinil: Attenuating Performance Effects Due to Sleep-Loss Over an Eighty-Eight Hour Period  
P. Hickey, J. Whitmore, J. Fischer

The Efficacy of Modafinil as an Operational Fatigue Countermeasure Over Several Days of Reduced Sleep  
J. French, J. Whitmore, Maj B. Doan, Maj W. Hurtle, Capt J. Kisner, 2Lt T. Heintz, J. Fischer, & P. Hickey

Methodology for Evaluating the Simulator Flight Performance of Pilots  
2Lt J. Smith and Dr. J. A. Caldwell

The sensitivity of several oculometric measures in relation to fatigue stress  
Dr. J. C. Miller, Dr. D. Eddy, and J. Fischer

Cognitive Performance Following Sudden Awakening While Under the Influence of Zolpidem and Melatonin  
Dr. D. Eddy, P. Hickey, K. Ramsey, & C. Welch.

## UP COMING EVENTS

### MILITARY AVIATION FATIGUE COUNTERMEASURES COURSE,

**August 25 - 26, 2004, Brooks City-Base, San Antonio, Texas**  
John Caldwell, Ph.D., Lynn Caldwell, Ph.D., James C. Miller, Ph.D., CPE

A 2-day fatigue management course will be conducted at Brooks City-Base in San Antonio, Texas. This course, which will be presented quarterly, will outline the dangers of fatigue in military aviation and related operations, the basic mechanisms underlying fatigue, the most common causes of overly-tired personnel, and the best techniques for optimizing alertness in military environments. Participants will receive instruction on the effective design of crew work/rest schedules and the use of a computerized scheduling tool. A short overview of research topics will be included as well. No prior education in fatigue management, sleep, or circadian rhythms is required. The cost of this course will be \$120.00 to cover the expense of two continental breakfasts and the take-home books containing course-related materials. Credit cards will be accepted. There is an additional charge for those requesting CME credits. Additional information and advanced course registration (required) is available at  
<http://www.brooks.af.mil/AFRL/HEP/HEPF/workshop.htm>

## ***The WFC Team just completed data collection:***

### **An Examination of Circasemidian Rhythms in Human Body Temperature, Sleepiness and Response Time:** Principal Investigator – Dr. J. Miller

Data collection for this study was completed in May and is currently under analysis. The objective of this study is to measure human physiological, subjective and behavioral first-harmonic (12-h) circasemidian rhythms under relatively constant environmental conditions, and to describe them quantitatively with respect to gender and age. This study will help AFRL determine whether we need to take into account circasemidian rhythms in physiology and performance and relevant environmental exposure factors in our efforts to provide operational risk management solutions for fatigued operators.

## **Future Studies**

### **Fatigue in Military Resident Physicians, 2004-2005:** Principal Investigator – Col R. DeLorenzo

The objective is to document fatigue in military resident physicians during the 2004-2005 academic year, using objective measures and robust controls, comparing the effect of different work schedules upon fatigue, and to obtain laboratory specimens during fatigued and rested states in order to search for fatigue biomarkers. Fatigue is a pervasive issue in residency training as well as in many military operations. This study will provide objective data to residency directors and planners. The data will be valuable in development and validation efforts for the Fatigue Avoidance Scheduling Tool (FAST™) fatigue-modeling program, which is currently being used in prototype form in military operational planning and mishap investigations. In collaboration with the Clinical Research Facility at Wilford Hall Medical Center and AFRL/HEPB at Wright-Patterson AFB, this study will attempt to identify fatigue-induced protein changes through proteomic technology. Also, in collaboration with the Federal Aviation Administration Civil Aeromedical Institute, this study will attempt to identify fatigue-related genes through functional genomics.

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## **In the News**

### **Dr. J. A. Caldwell and his team get recognized as battling aviator fatigue**

Last year, researchers studied fatigue in F-117A Nighthawk pilots at Holloman Air Force Base, N.M. They looked at the effects of being awake for 37 hours on alertness and flight performance. Researchers said flight precision most noticeably changed between 9 a.m. and 2 p.m. of the second day of the test. Armed with this data, the scientists returned to Holloman a few months later for the modafinil study. Once again they repeated the same tests as before; but this time, the pilots were given modafinil. Scientists said that while the pilots were on the medication, their performance "significantly improved," especially after 25 hours without sleep. During the simulator tests, modafinil "significantly" reduced the effects of fatigue during flight maneuvers, researchers said. Until more research is done, scientists said modafinil should be viewed as an option to, but not as a replacement for, dextroamphetamine. A 100-milligram dose of modafinil was apparently less effective than three 10-milligram doses of dextroamphetamine. [http://www.capitalflyer.info/issues/4\\_18/news/1123-1.html](http://www.capitalflyer.info/issues/4_18/news/1123-1.html)

# A Sleepy Surprise

AFRL/HEPF Scientists teamed with the National Sleep Foundation (NSF) to kick off a nationwide initiative to educate children and their parents about the importance of sleep for learning, health, and safety. The team spent two hours educating over 200 Inez Foster Elementary School children on 11 Mar 04 at in San Antonio, TX. The P.J. Bear project aims to reduce society's growing problem with chronic sleep restriction by teaching its youngest members that sufficient daily sleep is the key to improving performance, health, safety, and general well-being in all walks of life. The project conveys this information via classroom activities and comic-book-style educational materials designed to appeal to children aged 6-10. The highlight for the youngest age group is the opportunity to actually meet P.J. Bear-a big, furry, bear dressed in purple pajamas. This was P.J. Bears first trip to a real elementary school. The kids loved it and the NSF was extremely grateful for the efforts of AFRL/HEPF in the education of children about sleep.



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[http://www.brooks.af.mil/AFRL/HEP/HEPF/pj\\_bear.htm](http://www.brooks.af.mil/AFRL/HEP/HEPF/pj_bear.htm) and  
[http://www.brooks.af.mil/AFRL/HEP/HEPF/wfc\\_news.htm](http://www.brooks.af.mil/AFRL/HEP/HEPF/wfc_news.htm)

## WFC Team members receive prestigious awards

The President of the Life Sciences and Biomedical Engineering Branch (LSBEB) of the Aerospace Medical Association (AsMA), informed **Dr. Brandon Doan**, Major, USAF, BSC, that the LSBEB Award Committee, with Dr. Ted Knox as chairman, selected him as the winner of LSBEB A. *Howard Hasbrook Award* for 2004. This award, presented in conjunction with the AsMA Annual Scientific Meeting, recognizes an individual who has provided noteworthy data or design with respect to safety, survivability or crashworthiness relevant to aircraft or space vehicles. It is sponsored by US Aviation Underwriters.

The University of Illinois Institute of Aviation established an Aerospace Human Factors Association endowment to fund the *Henry L. Taylor Founder's Award*, for outstanding contributions in the field of aviation human factors. The Aerospace Human Factors Association annually solicits nominations for the award. The criteria for evaluating the nominations are as follows: (1) research and publications; (2) special original contributions, e.g., equipment, techniques, and procedures; or (3) general leadership in the field, e.g., teacher, director of laboratory, officer scientific societies, etc. The Institute of Aviation annually provides a \$500.00 honorarium to the selected participant. The winner for the 2004 award was announced at the annual business meeting of the Aerospace Human Factors Association.

The 2004 Henry L. Taylor Founder's Award was presented to **William Storm**, Ph.D., NTI, Incorporated

For over 30 years the WFC R&D Program has delivered counter fatigue products that enhance warfighter combat effectiveness in global mission extremes demanding night, sustained and 24/7 mental and physiological supremacy. We give American warfighters the "edge" to overcome physiological realities and win.